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Status of coastal plantations and its impact on land stabilization, soil P^H and salinity at Nolchira range of Hatiya Island, Bangladesh.

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Abstract: *The study was conducted to explore the status of coastal plantations, land accretion, erosion and stabilization at Nolchira Range of Hatiya Upa-zila of Noakhali district, Bangladesh. Among four beats of Nolchira coastal Range, Ochkhali and Dalchar beats were selected. Sample plots of 20m×20m (400m^2) were taken randomly for mangrove plantation. For highway, embankment and feeder road plantations, 50m long strips were selected for the vegetation sampling. In Nolchira forest range of Hatiya Island about 14370.73 ha of newly accreted land was planted by Sonneratia apetala of which 12450.62 ha was stabilized during the period of 1967 to 2007 under Coastal Afforestation Project (CAP), Mangrove Afforestation Project (MAP), 2nd Forestry Project, Forest Resource Management Project (FRMP) and Revenue projects in Nolchira range. The rest 1920.11 ha was eroded by river and wave action. 27 years old Sonneratia apetala attained 21 cm dbh and 16.5 m height growth in Ochkhali beat, whereas 27 years old Sonneratia apetala attained 24.5 cm dbh and 18.5 m height growth in Dalchar beat. Whereas, 27 years old Albizia saman attained 54 cm dbh in Ochkhali highway plantations, 40 cm in 14 years old embankment and 16.4 cm in 12 years old feeder road plantations respectively. Similarly, Acacia auriculiformis attained the dbh of 37 cm, 19.6 cm and 10.5 cm respectively for the same site. Whereas, Casuarina equisetifolia attained the dbh of 17 cm, 13.5 cm and 12.5 cm respectively in the same site. The soil P^H and salinity showed lower in old coastal plantation in comparisons in comparison to uri-grass land and newly accreted char lands. Among 12450.62 ha of stabilized coastal lands, 795 ha mature forest land was already converted into agricultural land. The stabilized coastal plantations protected the coastal environment of Hatiya Island from the severe loss and damage of coastal lives and properties due to the catastrophic effect of super cyclone SIDR in November 2007.*
Keywords- *coastal plantations, coastal environment, mangrove, land stabilization, soil P^H and salinity.*

I. Introduction

Bangladesh is a pioneer country with regard to coastal planting among the South East Asian countries (Siddiqi, 2001). Being exposed to the direct wind and wave action, the coastal environment is highly unstable. Moreover, the life and properties of the coastal plantation is always at risk (Saenger and Siddiqi, 1993). However, the newly accreted lands are mostly unsuitable for any land practices except afforestation because of a number of unpredictable geo-morphological changes, viz. rapid accretion, sand smoothening, sediment winnowing and rapid siltation or sandune movements (Das and Siddiqi, 1985). The primary pneumataphore of coastal species spread up laterally and persist within the silt layer for a longer time which also hasten the procedure of depositing and fixing silts, and thus helps in stabilization of lands (Siddiqi, 2001).

It is believed that a permanent green belt along the shoreline and near the shore and offshore islands would considerably reduce the losses incurred from the frequent cyclones and tidal surges, increase forest resources and provide ecological security to the coastal area as a whole. With this in view, establishment of massive mangrove plantation program was a concept in the forestry practices. Except mangroves in the natural Sundarbans, the long shoreline of the country was without tree cover till the beginning of the regular mangrove afforestation program in 1966 (Haque, 1984). Till now, an area of about 170,000 hectares has been planted with mangrove species under the coastal afforestation divisions of Chittagong, Noakhali, Barisal and Patuakhali (Hossain *et el*, 2008).

Land accretion in the coastal areas was going on since time immemorial but due to the absence of successful practices the ultimate gain in landmass stabilization is not significant. The Ganges, the Brahmaputra and Meghna are flowing through Bangladesh and on its way to the Bay of Bengal, these rivers carries an estimated load of 2.4 billion tons of sediments (Siddiqi, 2002). These sediments are subjected to coastal dynamic processes generated mainly by river flow, tidal and wind action, leading accretion and erosion without the development of deep rooted vegetation, where new formations remain unstable and surface erosion is a continuous phenomenon (Haque, 1984). Protection in certain areas of new coastal formation have been attempted through coastal afforestation programs. Afforestation in the new accreted land not only helps in the retention of deposited soil particle, but also hastens the process of raising the land above the tide level (Hasan, 1987). Through the afforestation project, the incoming silt load intercepted by existing stems, twigs, roofs and

fallen leaves of the plantations. This accelerates the siltation process and in this way the site gets silted and raised in an accelerated manner.

Noakhali Coastal Afforestation Division was established in the year of 1966-67 for raising coastal plantations in the newly accreted Char lands. The Nolchira Range is situated at the north-eastern side of Hatiya Upazilla in Noakhali district. Till 2007, a total of 14370.73 ha coastal plantations was planted in the Nolchira coastal forest Range of Hatiya Island in Noakhali district of Bangladesh. The study was carried out to assess the role of coastal plantations on land stabilization along with exploring coastal afforestation effect on soil P^H, salinity and coastal environment protecting itself from natural disaster viz. cyclones, tornadoes, floods, etc.

II. Materials And Methods

The study was conducted from January 2007 to December 2007 in Nolchira range of Hatiya Upazilla in Noakhali district that was administered by Noakhali Coastal Afforestation Division. Before 1967, the area of Hatiya Island was small in compare to the present land mass. Though accretion and erosion is a continuous process, a large sized landmass has been stabilized at Northern and western side of Hatiya after the establishment of coastal plantations. The range consists of 4 beats namely Ochkhali, Gashiar Char, Char Nurul Islam and Dalchar Beat. Considering the limitations of time and accessibility, the present study was concentrated only in Ochkhali and Dalchar beats of the coastal forest Range.

15 plots of size 20 m x 20 m were taken for 27 years old *Sonneratia apetala* and *Avicennia officinalis* from both the Ochkhali and Dalchar beast by simple random sampling methods for determining the growth performance of the plantations. Ten plots of 50 meter long strips were taken for each highway, embankment and feeder road plantations to assess the growth and development of non-mangrove species. A total of 15 randomly selected coastal soil sample plots (05 plots from each land type) (newly accreted charlands, uri-grass lands and 27 years old *Sonneratia and Avicennia* plantations) were collected from the depth of 0-5cm, 5-15 cm and 15-40 cm respectively with the help of soil auger, packed, labeled and carried to the Institute laboratory for chemical analysis.

a. Determination of soil P^H and salinity (1:2 soil-water ratios)

20g moist soil was taken in a clean dry 50 ml beaker and 40 ml of distilled water was added. The content was thoroughly stirred with a glass rod for half an hour. The P^H of the suspension was measured using digital P^H meter (TOA, Japan). Before taking P^H reading of the soil suspension, the meter was standardized using buffer solution of P^H 7 (Black *et al.* 1965). Similarly for measuring soil salinity, the mixture in the same ratio was then kept overnight for the settlement of the suspended materials and clear solution was then obtained by filtering through Whitman filter paper No. 1. The salinity of the soil sample was then measured from the solution using digital conductivity meter. The salinity was then calculated by reading of the salinity meter $\times$ $0.967 \times 10^{-6} \times 10 \times 100$ dsm^{-1}.

III. Results And Discussion

a. Mangrove plantation and land stabilization

A Total of 14370.07 ha of coastal plantation were planted during 1967 – 2007 in the Nolchira Range of Hatiya Upa-zila (Table 1). *Sonneratia apetala* was the pioneer species on the accreted char land followed by *Avicennia officinalis*.

Table 1. Status of mangrove plantation and land stabilization in Nolchira Range, Hatiya

Plantations established under the project	Plantation Year	Plantation area (ha)	Eroded landmass (ha)	Stabilized land (ha)	Forest lands transformed into agri-land (ha)
Coastal Afforestation Project	1967-1980	1280.81	451.94	828.87	100
Mangrove Afforestation Project	1980-1986	1910.66	140.00	1770.66	150
2nd Forestry Project	1986- 1992	1379.26	130.97	1248.29	80
Forest Resource Management Project.	1992- 2000	7250.00	790.00	6460.00	45
Revenue budget	2002 -2003	150.00	50.00	100.00	20
Forest Resource Management Project.	2003- 2007	2400.00	357.20	2042.80	400
	Total	14370.73	1920.11	12450.62	795

Among the total plantations, 12450.62 ha land became stabilized, whereas the rest 1920.11 ha was eroded by river and tidal waves. Moreover, 795 ha of the stabilized mangrove plantation already transformed into agriculture land (Table 1).

b. Growth performance of mangrove and non- mangrove species

Sonneratia apetala (Keora) was the dominant species in coastal afforestation programs of Hatiya Upazila followed by *Avicennia officinalis* (Baen). The mean dbh for *S. apetala* (Keora) and *A. officinalis* (Baen) was found 20 cm and 10 cm respectively at 27 years old coastal plantations in Ochkhali beat whereas it was found 24.5 cm and 12 cm respectively in Dalchar beat for the same aged plantations (Table 2). Height (m) of 27 years old *Sonneratia* plantations was 18.5 m in Dalchar beat, but it was 16.5 meter in Ochkhali beat (Table 2). Plantations established in highway, embankment and feeder road showed that *Albizia saman* (Rain tree), *Acacia auriculiformis* (Akashmoni), *Casuarinas equisetifolia* (Jhau) and *Leucaena leucocephala* (Ipil-Ipil) showed promising growth performance considering mean dbh and mean height. Maximum dbh (54 cm) was found in 27 years old *Albizia* spp. in highway plantations (Table 2). The dbh for rain tree was found 40cm in 14 years old embankment plantations, whereas it was found 16.4cm in 12 years feeder road plantations. The mean dbh and height for different species of highway, embankment and feeder road plantation were found satisfactory that had been established after land stabilization.

Table 2. Growth performance of mangrove and non- mangrove species in Nolchira Range of Hatiya Upazila.

Sampling site and area surveyed	Plantation age (Year)	Plantation type	Species	Mean dbh (cm)	Mean height (m)
Ochkhali (50 ha)	27	Coastal char land	*Sonneratia*	21	16.5
			Avicennia	10	2
Dalchar (300 ha)	27	Coastal char land	*Sonneratia*	24.5	18.5
			Avicennia	12	3.5
Ochkhali (50m long plot)	27	Highway	*Albizia*	54	35.5
			Acacia	37	26.5
			Casuarina	17	32.5
Ochkhali (50m long plot)	14	Embankment	*Albizia*	40	27.4
			Acacia	19.6	20.4
			Casuarina	13.5	20
			Leucaena	10.5	14.5
Ochkhali (50m long plot)	12	Feeder road	*Albizia*	16.4	13.5
			Acacia	10.5	11.2
			Casuarina	12.5	15.5

Haque *et al* (2000) reported *S. apetala* showed average diameter growth of 12.46 cm at 25 year age while 16.25 cm at 23 year age; and 6.12 cm at 6 year age while 11.51 cm at 5 year age. Similarly, *A. officinalis* showed average diameter growth of 9.52 cm at 16 year age and 14.57 cm at 15 year age. Haque *et al* (2000) also reported growth in diameter and height, and standing volume in wood per unit area were not related with the age of the plantations for the species while studying at the Mirersarai and sitakunda coastal forest ranges. Diameter growth showed wider range at some locations for the same age of all the species except *Avicennia officinalis* at different sites. This was due to too much variation in density of the species within the same age as well as due to variations in site condition.

Siddiqi and Khan (1990) reported the growth performance of *S. apetala* and *A. officinalis* was found lower in the Mirersarai and sitakunda coastal forest ranges under Chittagong coastal afforestation division compared to sample plots in Patuakhali, Bhola and Noakhali coastal afforestation division as well as other areas in Chittagong coastal afforestation areas.

3.3. Soil P^H and soil salinity

In regard to the soil chemical properties, the P^H and salinity of the soil varied among mangrove forest, grass land (uri-grass) and newly accreted char land. The soil P^H was found 7.8 at the depth of 0-5cm in stabilized coastal plantation, whereas the P^H was found 8.0 in grass land and 8.1 in newly accreted char land respectively at the same depth (Table 3).The soil P^H was found 7.6 cm, 7.9 cm, 8.1 cm respectively at the depth of 15-40 cm in stabilized coastal plantation, grass land (Uri- grass) and newly accreted char land respectively. The soil P^H was found comparatively lower in stabilized coastal plantations in comparison to grass land and newly accreted char land (Table 3). Similarly, the soil salinity were found 7.1 dsm^{-1}, 8.1 dsm^{-1} and 9.0 dsm^{-1} at the depth of 0-5 cm in coastal plantation, uri-grass land and newly accreted char land respectively.

Table 3. Soil P^H and salinity of stabilized coastal plantations, uri-grassland and newly accreted char lands in Nolchira Range, Hatiya.

Coastal sites	Soil depth (cm)	Soil P^H	Soil salinity (dsm^{-1})
27 year old coastal plantation	0-5	7.8	7.1
	6-15	7.7	8.1
	16-40	7.6	9.0
Char lands with Uri grass	0-5	8.0	8.1
	6-15	7.9	9.1
	16-40	7.9	9.8
Newly accreted barren char land	0-5	8.1	9.0
	6-15	8.0	10.8
	16-40	8.1	9.5

Soil salinity was found maximum (10.8 dsm^{-1}) at the depth of 5-15 cm in newly accreted char land directly exposed to the Bay of Bengal whereas it was found minimum (7.1 dsm^{-1}) at the depth of 0-5 cm in the stabilized coastal plantations (Table 3). The soil P^H and salinity were varied at different depths in different land strips. It was lower in old coastal plantations in comparison to grass land and newly accreted char lands (Table 3). The soil P^H value ranges from 7.6 to 8.1 (Table 3), which supports the findings of Siddiqi (2001). Similarly, the salinity ranges from 7.1 to 10.8 dsm^{-1} and increased trend were found in newly accreted char lands in comparison to old plantations (Table 3).

Shaifullah et al (2009) while studying coastal afforestation effect of soil properties at Hatiya in Bangladesh reported the soil P^H was significantly ($p\leq0.05$, $p\leq0.01$, $p\leq0.001$) higher and soil salinity was significantly($p\leq0.001$) lower at the soil depth of 0-10 cm across three different land strips viz. inland, middle and seaside in 12- and 17-year old *Sonneratia apetala* (Keora) plantations of Char Alim and Char Piya in comparison to the adjacent barren lands at Char Rehania and Char Nurul Islam in Hatiya Island of Noakhali district, Bangladesh. The soil P^H and salinity was found 7.07 and 0.09 $dscm^{-1}$ respectively at surface soil in inland plantation of Char Alim, whereas it was found 6.57 and 0.13 $dscm^{-1}$ respectively at the same depth of adjacent barren land in Char Rehania. He also reported soil P^H and salinity were increased from inland towards seaside in the plantations.

Shaifullah *et al* (2008) reported the highest reduction in soil P^H was recorded at surface (0-10 cm soil depth) soil (7.27 to 6.60) across the sea side and subsurface (10-45 cm soil depth) soil (7.16 to 6.67) in inland due to influence of coastal plantations. Shaifullah *et al* (2008), while studying the coastal afforestation effect of soil on the Luxmipur coast of Bangladesh found to have significant lowering effect on soil P^H at surface and subsurface soil depths. Lowering of salinity through keora plantation was also reported by Kabir (2005). Cardona and Boetro (1998) found that soil salinity in the Carribbean increased from land toward sea side.

Tam and Wong (1998), while studying the variations of soil nutrient and organic matter content in a subtropical mangrove ecosystem, recorded that P^H changes along tidal gradients were directly affected by degree of litter production and decomposition. He also reported that the narrower plant coverage and less litter production the more the alkaline P^H. Similar result was also recorded by Lacerda *et al*. (1995) and Tam *et al* (1993). This is probably due to the release of various organic acids through the hydrolysis of tannin in mangrove plants and breakdown of carbonic matter content in litter (Steinke *et al*. 1993).

IV. Conclusion

Coastal plantations play an important role in reducing the vulnerability of coastal people to natural disasters. A total of almost14370.73 ha of newly accreted char land were plated by pioneer coastal mangrove species where approximately 12450.62 ha of land were stabilized. Almost 795 ha of a stabilized great landmass were transformed into agricultural land in Nolchira Range of Hatiya Island in Bangladesh which ultimately showed that the land was highly stabilized. The plantations act as a bio-shield to safe guard the coastal people and in the long-term changes the topography through processes of sediment accretion and land stabilization. The fringe-like root systems of the *Sonneratia* (Keora)/ *Avicennia* (Baen) plantations act as a coastal land stabilizer and binders of sediments. It prevents the soil erosion and gradually stabilized the newly accreted land that may contribute to the landmass gaining from the Bay of Bengal. The soil P^H and salinity were varied at different depths in different land strips. The soil P^H and salinity were found comparatively lower in stabilized coastal plantations in comparison to grass land and newly accreted char land. However, local residents reported (2007) that coastal plantations in Hatiya Island protected thousands of lives and properties of coastal environment from the catastrophic effect of super cyclone SIDR that was attacked on the coast of Bangladesh on November 15, 2007. Whereas the number of deaths was remarkable in this area due to the cyclonic attack in Aril 29, 1991 because of lacking stabilized coastal plantations.

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